BRIEF ON APPEAL

Application #	09/700,185
Confirmation #	2588
Filing Date	December 18, 2000
First Inventor	ARAKI
Art Unit	1745
Examiner	Ruthkosky, Mark
Docket #	P06971US00/BAS

APPEAL FROM THE FINAL REJECTION MAILED JUNE 16, 2003

TABLE OF CONTENTS

1. REAL PARTY IN INTEREST

The real party in interest is the Assignee, Daikin Industries, Ltd.

2. RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences.

3. STATUS OF CLAIMS

Claims 1 and 5-44 are pending in the present application. Claims 1, 5, 6, 7, 14, 15 and 16 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Massayuki et al (JP 06-260,184; hereinafter "JP '184"). Claims 1, 5, 6, 7, 14-21 and 41 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Harada (U.S. 5,399,184). Claims 8-13, 22-40 and 42-44 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Harada.

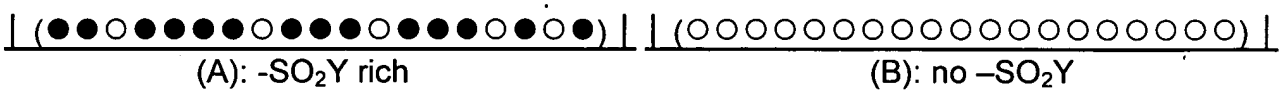
4. STATUS OF AMENDMENTS

The Amendment After Final Rejection filed on November 17, 2003 in response to the Final Office Action of June 16, 2003 was entered per the Advisory Action dated December 16, 2003.

5. SUMMARY OF THE INVENTION

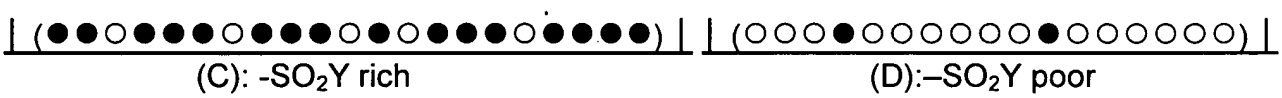
The present invention relates to a material for a solid polyelectrolyte. The material comprising a multi-segmented fluoropolymer, which is produced by combining segment A (a random copolymer of an ethylenic fluoromonomer unit containing sulfonic acid functional groups, (●) and an ethylenic fluoromonomer unit containing no sulfonic

acid functional groups (○)) and segment B (a polymer of an ethylenic fluoromonomer unit containing no sulfonic acid functional groups (○)). The segments A and B are in the form of blocks or graft which comprise the multi-segmented fluoropolymer The multi-segmented fluoropolymer comprising segments A and B is schematically shown below as (A)-(B) block copolymer:



The present invention also relates to a material for a solid electrolyte comprising a multi-segmented fluoropolymer, which is produced by combining segment C (a fluoropolymer chain segment with a higher sulfonic acid functional group content) and segment D (a polymer chain segment with a lower sulfonic acid functional group content) in the form of blocks or graft.

The multi-segmented fluoropolymer comprising segments C and D is schematically shown below (●:with $-SO_2Y$, ○:without $-SO_2Y$):



In the examples disclosed in the present specification, after segment A or C is produced, segment B or D is block-copolymerized to segment A or C, respectively. Thus, segment A, B, C and D are produced separately to form a block.

Segment A or C imparts good ion conductivity to the material for a solid electrolyte and segment B or D imparts good mechanical properties thereto. Accordingly, the material

for a solid electrolyte of the present invention has both good ion conductivity and good mechanical properties.

In the present invention, in one form, the multi-segmented fluoropolymer is produced by combining a segment A with a segment B in the form of blocks or a graft as shown in Fig. 1 of the present specification (a copy of which is included in Appendix 1 to this Appeal Brief), where:

segment A : a random copolymer containing an ethylenic fluoromonomer unit containing sulfonic acid functional groups and an ethylenic fluoromonomer unit containing no sulfonic acid functional groups.

segment B : a polymer containing no sulfonic acid functional groups.

The present invention also relates to a material for a solid polyelectrolyte, comprising a multi-segmented fluoropolymer having at least two types of fluoropolymer chain segments C and D containing sulfonic acid functional groups, the fluoropolymer chain segment C having a smaller equivalent weight than the fluoropolymer chain segment D.

This multi-segmented fluoropolymer is also produced by combine a segment C with a segment D in the form of blocks or a graft as shown in the <Reference Figure> of Appendix 1, where:

segment C : a random copolymer containing an ethylenic fluoromonomer unit containing sulfonic acid functional groups (higher content) and an ethylenic fluoromonomer unit containing no sulfonic acid functional groups.

segment D : a random copolymer containing an ethylenic fluoromonomer unit containing sulfonic acid functional groups (lower content) and an ethylenic fluoromonomer unit containing no sulfonic acid functional groups.

In the present invention, the use of the specific copolymer Segments A and B or Segments C and D in the form of blocks or a graft improves the mechanical properties, high temperature mechanical properties, heat resistance, ion conductivity, and other properties of the fluoropolymer.

Further, when the fluoropolymer is used as a material for a solid polyelectrolyte in a fuel cell, it effectively improves the heat resistance, durability, and creep resistance; and thus increasing the reliability.

6. ISSUES

Issue 1: Are claims 1, 5, 6, 7, 14, 15 and 16 patentable under 35 U.S.C. § 102(b) in view of JP '184.

Issue 2: Are claims 1, 5, 6, 7, 14-21 and 41 patentable under 35 U.S.C. § 102(b) in view of Harada.

Issue 3: Are claims 8-13, 22-40 and 42-44 patentable under 35 U.S.C. § 102(a) in view of Harada.

7. GROUPING OF CLAIMS

For each ground of rejection which Applicants traverse which apply to more than one claim, such additional claims, to the extent separately identified and argued below, do not stand or fall together.

8. ARGUMENT

All pending claims are clear of the prior art which fails to teach or suggest a multi-segmented fluoropolymer having a segment A and segment B or segment C and segment D as claimed. It is respectfully submitted that the prior art rejections are based on a misinterpretation of the claimed multi-segmented fluoropolymer with respect to the prior art random fluoropolymers as discussed below in detail.

The claimed "multi-segmented fluoropolymer" of the present invention will be understood by one of ordinary skill in the art to be a fluoropolymer comprised of discrete segments in the form either blocks or grafts or a combination thereof (see, e.g., present specification page 11, lines 4-20; U.S. Patent No. 6,699,941 (hereinafter "the '941 patent"); and U.S. Patent No. 6,552,131 (hereinafter "the '131 patent")). The IUPAC accepted definition of a "block copolymer" is a copolymer that is a block polymer where adjacent blocks are constitutionally different, i.e., each of these blocks comprises constitutional units derived from different characteristic species of monomer or with different composition or sequence distribution of constitutional units. The term "block" is a portion of a macromolecule, comprising many constitutional units that has at least one feature which is not present in the adjacent portions. (See Glossary of Polymer Terminology, IUPAC definition attached as Appendix 2 to this Appeal Brief).

Further, one of ordinary skill in the art would understand that each block or segment is of a significant size relative to the individual constitutional units, i.e., monomers. For example, typical blocks or segments forming a block copolymer will be around 1,000 to 1.2 million in molecular weight as is disclosed in the '941 patent where segments A, A' are between 3,000 and 60,000 and segment B is between 30,000 and

300,000; and the present specification, page 23, lines 1-10 where segment A has a molecular weight of 5,000 to 1 million, segment B, 1,000 to 1.2 million, segment C, 1,000 to 1 million and segment D, 1,000 to 1.2 million.

a. JP '184 Does Not Anticipate Claims 1, 5, 6, 7, 14, 15 and 16 Under 35 U.S.C. § 102(b) As JP '184 Fails To Disclose The Claimed Multi-Segmented Fluoropolymer

The present invention is novel and not obvious in view of the prior art of record.

The present invention as recited in claim 1, relates to a material for a solid polyelectrolyte, comprising a multi-segmented fluoropolymer having:

a fluoropolymer chain segment A containing sulfonic acid functional groups, which is a copolymer comprising:

(a) an ethylenic fluoromonomer unit containing sulfonic acid functional groups represented by Formula (1)

$$CX_2\text{-}CX^1\text{-}(O)_n\text{-}Rf\text{-}SO_2Y \qquad (1)$$

wherein X and X^1 may be the same or different and are each hydrogen or fluorine; Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s); and n is 0 or 1; and

(b) at least one type of ethylenic fluoromonomer unit copolymerizable with the ethylenic fluoromonomer unit and containing no sulfonic acid functional groups;

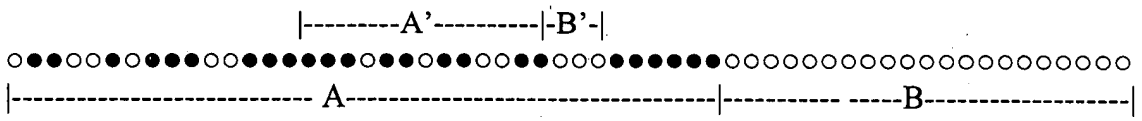
and a fluoropolymer chain segment B containing no sulfonic acid functional groups, the fluoropolymer chain segment B having a crystalline melting point of 100°C or higher or a glass transition point of 100°C or higher.

JP '184 discloses a copolymer fluoropolymer comprised of random ethylenic fluoromonomer subunits either containing or not containing sulfonic acid functional groups. In the examples of JP '184, the ethylenic fluoromonomer containing sulfonic acid functional groups and an ethylenic fluoromonomer containing no sulfonic acid functional groups is copolymerized in the presence of polymerization initiator. Accordingly, the copolymer obtained in JP '184 is a random copolymer. JP '184 does not disclose about segmented copolymer containing at least two discrete segments as claimed.

Further, JP '184 only discloses a copolymer fluoropolymer corresponding to the segment A of the present invention.

During the Examiner Interview of May 12, 2004, the Examiner alleged that the claimed segment A and segment B could be satisfied by the copolymer of JP '184. Using the symbol notation above where "●" represents an ethylenic fluoromonomer containing no sulfonic acid functional groups and "○" represents an ethylenic fluoromonomer containing sulfonic acid functional groups, the Examiner alleged that JP '184 which discloses a copolymer equivalent to segment A could be pursed or divided into subparts which would anticipate both segments A and B. The Examiner alleged that JP '184 copolymer analogs to segment A (i.e., a string of fluoromonomer units containing either sulfonic acid functional groups and not containing sulfonic acid functional groups followed by a series of fluoromonomer units not containing sulfonic acid functional groups) could also be read to anticipate both segments A and B if

segment A were read as comprising a segment A' and segment B' as depicted in the figure below.



Figure

Thus, the Examiner's position is that JP '184 teaches a polymer which contains a string of fluoromonomer subunits, i.e., A' and B', which can be read to be claimed segments A and B.

Contrary to the Examiner's interpretation, one of ordinary skill in the art would not parse the random copolymer of JP '184 into alleged segments A' and B' to read on the claimed segments A and B. As discussed above, a multi-segmented fluoropolymer comprises blocks of substantial size, i.e., molecular weight. Thus, an alleged string of a few monomer subunits, e.g., A' or B', would never be referred to by one of ordinary skill in the art as a "block" or "segment" of a multi-segmented fluoropolymer.

Although JP '184 may teach a random copolymer containing an ethylenic fluoromonomer unit containing sulfonic acid functional groups and an ethylenic fluoromonomer unit containing no sulfonic acid functional groups similar to segment A, which may include a series of several fluoromonomers containing sulfonic acid functional groups, JP '184 fails to teach or suggest segment B, a fluoropolymer segment or block containing no sulfonic acid functional groups. Accordingly, JP '184 fails to teach or suggest a multi-segmented fluoropolymer having both segment A and segment B.

Based on the foregoing discussion, claim 1 is not anticipated by JP '184.

Further, claims 5-7, and 14-16 are not anticipated under 35 U.S.C. § 102(b) by JP '184 for reciting additional elements not taught by JP '184. Therefore, claims 5-7 and 14-16 are not anticipated by JP '184 under 35 U.S.C. § 102(b).

b. <u>Claims 1, 5-7, 14-21 and 41 Are Not Anticipated Under 35 U.S.C. § 102(b) By Harada As Harada Fails To Teach The Claimed Multi-Segmented Fluoromonomer Comprising Segments A and B or Segments C and D As Claimed</u>

Harada discloses a cation exchange membrane comprising a copolymer of the following formula.

$$((CF_2\text{-}CF_2)_k\text{-}(\underset{\displaystyle |\atop \displaystyle OCF_2CF(CF_3)OCF_2CF_2SO_3X}{CF}\text{-}CF_2))_1$$

Using the ○/● notation above, it is apparent for those skilled in the art that a following formula;

$$((CF_2\text{-}CF_2)_k\text{-}(\underset{\displaystyle |\atop \displaystyle OCF_2CF(CF_3)OCF_2CF_2SO_3X}{CF}\text{-}CF_2))_1 \qquad ((\circ)_k - (\bullet)_1)$$

does not represent a block copolymer of (○) and (●), but represents a random copolymer of k mole of (○) and 1 mole of (●).

In other words, the above formula of Harada does not represent a block copolymer of:

●●○●●●○○●○●●●○●●○●●○○○○○○○○○○○○○○○○○○○○

(e.g., claim 1), or

○○○○○○○○○○○○○○○○○○○○●●●●●●●●●●●●●●●●●

(e.g., claim 8), but represents a random copolymer of

○●●○●○○○●●●●○○○○●●●●○○●○○●●●●○○●○●●○●●●●

Harada does not disclose producing a segment comprising monomer (●) and/or monomer (○). Accordingly, the copolymer of Harada is a random copolymer.

Moreover, like JP '184, Harada only discloses a copolymer corresponding to segment A of the present invention. While, *arguendo*, Harada teaches a random copolymer which comprises strings of monomer subunits, it would be repugnant to the ordinary meaning of the term "block" or "segment" as understood by one of ordinary skill in the art refer to a string of a few similar monomers within a random copolymer as "blocks" or "segments". As discussed above, a series of several monomer subunits would not be referred to as a block or segment of a multi-segmented polymer by one of ordinary skill in the art since a string of a few like monomers fails to meet the understood definition requiring "many" like units, typically in the molecular weight range of 1,000 to 1.2 million. Therefore, contrary to the Examiner's allegation that the random copolymer of Harada teaches both segments A and B, Harada merely teaches a copolymer corresponding to segment A.

Based on the foregoing, claim 1 is not anticipated by Harada under 35 U.S.C. § 102(b). Further, claims 5-7, 14-21 and 41 which recite additional elements not taught by Harada are not anticipated under 35 U.S.C. § 102(b).

For example, with specific reference to claim 41, Harada fails to teach a fluoropolymer chain segment A' having a molecular weight of 5,000 to 750,000 and a fluoropolymer chain segment B' having a molecular weight of 3,000 to 1,200,000.

c. Claims 8-13, 22-40 and 42-44 Are Not Obvious Under 35 U.S.C. § 103(a) In View Of Harada As Harada Fails To Teach or Suggest The Claimed Fluoromonomer Chain Segments C or D

Harada fails to teach or suggest the fluoropolymer chain segments C and D recited in claim 8. Contrary to the Examiner's allegation, it would not be obvious for one of ordinary skill in the art to vary the amounts of tetrafluoroethylene units disclosed in Harada to make the claimed multi-segmented fluoropolymer. First, Harada fails to teach or suggest any multi-segmented fluoropolymer but merely a random copolymer as discussed above. Second, Harada fails to teach or suggest any method by which one of ordinary skill in the art would produce a multi-segmented fluoropolymer having two distinct segments such as claims segments C and D. Third, one of ordinary skill in the art would not be motivated to modify the teachings of Harada to make a multi-segmented fluoropolymer having segments C and D as claimed. For example Harada does not disclose or suggest that the claimed particular block or graft copolymers have both good ion conductivity and good mechanical properties. Thus there fails to be any motivation for one of ordinary skill in the art to modify the teachings of Harada to make the claimed multi-segmented fluoropolymer obvious.

Claims 9-13, 29 and 37 depend from claim 8 and recite further elements not taught or suggested by Harada. Accordingly, claims 9-13, 29 and 37 are further not obvious in view of Harada.

Claim 22 is not taught or suggested by Harada as Harada fails to teach or suggest a multi-segmented fluoropolymer having chains C^1 and D^1 where C^1 is a copolymer having a molecular weight of 5,000 to 75,000 and D^1 is a fluoropolymer chain having a molecular weight of 3,000 to 1.2 million and represented by the specific formulas claimed. Thus while the claimed blocked copolymer comprises two segments or blocks C^1 and D^1 of substantial size, namely 5,000 to 150,000 (C^1) and 3,000 to 1.2 million (D^1), Harada merely teaches a string of random copolymers which may comprise a series of several monomer units but in no way does Harada teach or suggest the claimed molecular weight magnitude of segments C^1 and D^1.

Based on the foregoing, claim 22 is not obvious in view of Harada. Claims 23-28 and 42 which depend from claim 22 and recite further elements not taught or suggested by Harada are further not obvious by Harada under 35 U.S.C. § 103(a).

Claim 30 is not obvious by Harada as Harada fails to teach or suggest a multi-segmented fluoropolymer that comprises a block copolymer containing at least two types of fluoropolymer chain segments differing in monomer composition with at least one type of the fluoropolymer chain segments containing sulfonic acid functional groups. The Examiner admits that Harada does not specifically teach the polymer to be a block polymer (see June 16, 2003 Office Action, page 5, third paragraph). However, the Examiner alleges that Harada teaches in column 6 that the ion exchange capacity of the membrane can be varied by changing the molar ratio of tetrafluoroethylene units in the copolymer to the perfluorovinylether monomers with sulfonyl groups. Contrary to the Examiner's allegation, Harada fails to provide a sufficient or an enabling disclosure.

In order for a reference to be anticipatory, the Federal Circuit has determined that the reference must enable the claimed invention. See Elanpharm, Inc. v. Mayofound, 68 U.S.P.Q. 2d 1373 (Fed. Cir. 2003). Further, the Federal Circuit stated that enablement requires that "the prior art reference must teach one of ordinary skill in the art to make or carry out the claimed invention without undue experimentation".

Harada fails to teach or suggest how one of ordinary skill in the art would form a multi-segmented fluoropolymer that comprises a block copolymer containing at least two types of fluoropolymer chains differing in monomer composition. While, *arguendo*, Harada teaches a copolymer which may comprise a series of similar adjacent monomer units, e.g., three or four monomer subunits, Harada fails to teach or suggest a block copolymer as one of ordinary skill in the art would define.

Based on the foregoing, claim 30 is not obvious in view of Harada. Claims 31-36 and 38-40 depend from claim 30 and recite further elements not taught or suggested by Harada and thus are further not obvious in view of Harada.

d. Conclusion

In view of the foregoing, all pending claims are clear of the prior art which fail to teach or suggest the claimed multi-segmented fluoropolymer. Accordingly, all pending claims are patentable in view of the prior art cited.

9. APPENDIX: CLAIMS ON APPEAL

1. (Previously Presented) A material for a solid polyelectrolyte; said material comprising:

a multi-segmented fluoropolymer having a fluoropolymer chain segment A containing sulfonic acid functional groups, which is a copolymer comprising:

(a) an ethylenic fluoromonomer unit containing sulfonic acid functional groups represented by Formula (1)

$$CX_2=CX^1-(O)_n-Rf-SO_2Y \qquad (1)$$

wherein X and X^1 may be the same or different and are each hydrogen or fluorine; Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s); and n is 0 or 1; and

(b) at least one type of ethylenic fluoromonomer unit copolymerizable with the unit (a) and containing no sulfonic acid functional groups;

and a fluoropolymer chain segment B containing no sulfonic acid functional groups, the fluoropolymer chain segment B having a crystalline melting point of 100°C or higher or a glass transition point of 100°C or higher.

2-4. (Canceled)

5. (Previously presented) The material according to claim 1, wherein the at least one type of ethylenic fluoromonomer unit (b) containing no sulfonic acid functional groups comprises tetrafluoroethylene.

6. (Previously Presented) The material according to claim 1, wherein the fluoropolymer chain segment B is a polymer chain comprising 85 to 100 mol% of tetrafluoroethylene and 15 to 0 mol% of a monomer represented by Formula (3)

$$CF_2=CF\text{-}Rf^a \qquad (3)$$

wherein Rf^a is CF_3 or ORf^b and Rf^b is C_1 to C_5 perfluoroalkyl.

7. (Previously presented) The material according to claim 1, wherein the multi-segmented fluoropolymer has an equivalent weight of 400 to 1600.

8. (Previously presented) The material according to Claim 1, comprising a multi-segmented fluoropolymer having at least two types of fluoropolymer chain segments C and D containing sulfonic acid functional groups, the fluoropolymer chain segment C having a smaller equivalent weight than the fluoropolymer chain segment D.

9. (Original) The material according to Claim 8, wherein the fluoropolymer chain segment D has a crystalline melting point of 100°C or higher or a grass transition point of 100°C or higher.

10. (Original) The material according to Claim 8, wherein the fluoropolymer chain segments C and D containing sulfonic acid functional groups are each a copolymer comprising:

(c) an ethylenic fluoromonomer unit containing sulfonic acid function groups; and

(d) at least one type of ethylenic fluoromonomer unit copolymerizable with the unit (c) and containing no sulfonic acid functional groups.

11. (Previously presented) The material according to claim 10, wherein the ethylenic fluoromonomer unit (c) containing sulfonic acid functional groups is represented by Formula (1)

$$CX_2=CX^1-(O)_n\text{-}Rf\text{-}SO_2Y \qquad (1)$$

wherein X and X^1 may be the same or different and are each hydrogen or fluorine; Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s); and n is 0 or 1.

12. (Previously presented) The material according to Claim 8, comprising the multi-segmented fluoropolymer in which the fluoropolymer chain segment D has an equivalent weight of 1000 or more.

13. (Previously Presented) The material according to Claim 8, wherein the multi-segmented fluoropolymer has an equivalent weight of 400 to 1600.

14. (Previously presented) A solid polyelectrolyte membrane comprising the multi-segmented fluoropolymer according to claim 1.

15. (Original) The solid polyelectrolyte membrane according to Claim 14, wherein the multi-segmented fluoropolymer contains protonated sulfonic acid (SO_3H) groups as the sulfonic acid functional groups, and has a modulus of elasticity of at least $1X10^8$ dyn/cm^2 at 110°C or higher.

16. (Original) The solid polyelectrolyte membrane according to Claim 15, wherein the equivalent weight of the whole multi-segmented fluoropolymer is 1600 or less.

17. (Previously presented) A multi-segmented fluoropolymer having a fluoropolymer chain segment A^1 containing sulfonic acid functional groups and a fluoropolymer chain segment B^1 containing no sulfonic acid functional groups, wherein:

the fluoropolymer chain segment A^1 containing sulfonic acid functional groups is a copolymer having a molecular weight of 5000 to 750000 and comprising:

(e) 1 to 50 mol% of at least one type of structural unit represented by Formula (1)

$$CX_2=CX^1-(O)_n\text{-}Rf\text{-}SO_2Y \qquad (1)$$

wherein X and X^1 may be the same or different and are each hydrogen or fluorine; Y is F, Cl and OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s); and n is 0 or 1, and

(f) 99 to 50 mol% of at least one type of ethylenic monomer structural unit containing no sulfonic acid functional groups; and

the fluoropolymer chain segment B^1 is a fluoropolymer chain containing at least one type of ethylenic fluoromonomer unit and having a molecular weight of 3000 to 12000000.

18. (Previously presented) The multi-segmented fluoropolymer according to claim 17, wherein the ethylenic fluoromonomer (e) in the fluoropolymer chain segment A^1 is represented by Formula (2)

$$CF_2=CFO\text{-}Rf\text{-}SO_2Y \qquad (2)$$

wherein Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s).

19. (Original) The multi-segmented fluoropolymer according to Claim 17, wherein the ethylenic monomer (f) in the fluoropolymer chain segment A^1 contains at least one ethylenic fluoromonomer.

20. (Original) The multi-segmented fluoropolymer according to Claim 19, wherein the ethylenic monomer (f) is tetrafluoroethylene.

21. (Previously Presented) The multi-segmented fluoropolymer according to Claim 17, wherein the fluoropolymer chain segment B^1 is a polymer chain comprising 85 to 100 mol% of tetrafluoroethylene and 15 to 0 mol% of a monomer represented by Formula (3)

$$CF_2=CF\text{-}Rf^a \qquad (3)$$

wherein Rf^a is CF_3 or ORf^b and Rf^b is C_1 to C_5 perfluoroalkyl.

22. (Previously presented) A multi-segmented fluoropolymer having at least two types of fluoropolymer chain segments C^1 and D^1 containing sulfonic acid functional groups, wherein:

the fluoropolymer chain segment C^1 is a copolymer having a molecular weight of 5000 to 750000 and comprising:

(g) 13 to 50 mol% of at least one type of ethylenic fluoromonomer structural unit containing sulfonic acid functional groups and represented in Formula (1)

$$CX_2=CX^1\text{–}(O)_n\text{-}Rf\text{-}SO_2Y \qquad (1)$$

wherein X and X^1 may be the same or different and are each hydrogen or fluorine; Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s); and n is 0 or 1, and

(h) 87 to 50 mol% of at least one type of ethylenic monomer structural unit containing no sulfonic acid functional groups; and

the fluoropolymer chain segment D^1 is a fluoropolymer chain having a molecular weight of 3000 to 1200000 and comprising:

(i) not less than 0.1 mol% but less than 13 mol% of at least one type of ethylenic fluoromonomer unit containing sulfonic acid functional groups and represented by Formula (1)

$$CX_2=CX^1-(O)_n\text{-}Rf\text{-}SO_2Y \qquad (1)$$

wherein X, X^1, Y, n and Rf are as defined above, and

(j) more than 87 mol% but not more than 99.9 mol% of at least one type of ethylenic monomer unit containing no sulfonic acid functional groups.

23. (Previously presented) The multi-segmented fluoropolymer according to claim 22, wherein the ethylenic fluoromonomer (g) in the fluoropolymer chain segment C^1 is represented by Formula (2)

$$CF_2=CFO\text{-}Rf\text{-}SO_2Y \qquad (2)$$

wherein Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s).

24. (Original) The multi-segmented fluoropolymer according to Claim 22, wherein the ethylenic monomer (h) in the fluoropolymer chain segment C^1 contains at least one ethylenic fluoromonomer.

25. (Original) The multi-segmented fluoropolymer according to Claim 24, wherein the ethylenic monomer (h) in the fluoropolymer chain segment C^1 is tetrafluoroethylene.

26. (Previously presented) The multi-segmented fluoropolymer according to claim 22, wherein the ethylenic fluoromonomer (i) in the fluoropolymer chain segment D^1 is represented by Formula (2)

$$CF_2=CFO\text{-}Rf\text{-}SO_2Y \qquad (2)$$

wherein Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s).

27. (Original) The multi-segmented fluoropolymer according to Claim 22, wherein the ethylenic monomer (j) in the fluoropolymer chain segment D^1 contains at least one ethylenic fluoromonomer.

28. (Original) The multi-segmented fluoropolymer according to Claim 27, wherein the ethylenic monomer (j) in the fluoropolymer chain segment D^1 is tetrafluoroethylene.

29. (Previously Presented) A solid polyelectrolyte membrane comprising the multi-segmented fluoropolymer according to claim 8.

30. (Previously Presented) A material for a solid polyelectrolyte, comprising a multi-segmented fluoropolymer that comprises a block copolymer containing at least two types of fluoropolymer chain segments differing in monomer composition, at least one type of the fluoropolymer chain segments containing sulfonic acid functional groups.

31. (Previously Presented) The material according to claim 30, which comprises a multi-segmented fluoropolymer that comprises a block copolymer containing a fluoropolymer chain segment A containing sulfonic acid functional groups and a fluoropolymer chain segment B containing no sulfonic acid functional groups, the fluoropolymer chain segment B having a crystalline melting point of 100°C or higher or a glass transition point of 100°C or higher.

32. (Previously Presented) The material according to claim 31, wherein the fluoropolymer chain segment A containing sulfonic acid functional groups is a copolymer comprising:

(a) an ethylenic fluoropolymer unit containing sulfonic acid functional groups; and

(b) at least one type of ethylenic fluoromonomer unit copolymerizable with the unit (a) and containing no sulfonic acid functional groups.

33. (Previously Presented) The material according to claim 32, wherein the ethylenic fluoromonomer unit (a) containing sulfonic acid functional groups is represented by Formula (1)

$$CX_2=CX^1-(O)_n\text{-}Rf\text{-}SO_2Y \qquad (1)$$

wherein X and X^1 may be the same or different and are each hydrogen or fluorine; Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s); and n is 0 or 1.

34. (Previously Presented) The material according to claim 32, wherein the at least one type of ethylenic fluoromonomer unit (b) containing no sulfonic acid functional groups is tetrafluoroethylene.

35. (Previously Presented) The material according to claim 31, wherein the fluoropolymer chain segment B is a polymer chain comprising 85 to 100 mol% of tetrafluoroethylene and 15 to 0 mol% of a monomer represented by Formula (3)

$$CF_2=CF\text{-}Rf^a \qquad (3)$$

wherein Rf^a is CF_3 or ORf^b wherein Rf^b is C_1 to C_5 perfluoroalkyl.

36. (Previously Presented) The material according to claim 31, wherein the multi-segmented fluoropolymer has an equivalent weight of 400 to 1600.

37. (Previously Presented) The material according to claim 8, which comprises a multi-segmented fluoropolymer having a block copolymer of at least two types of fluoropolymer chain segments C and D containing sulfonic acid functional groups, the fluoropolymer chain segment C having a smaller equivalent weight than the fluoropolymer chain segment D.

38. (Previously Presented) A solid polyelectrolyte membrane comprising the multi-segmented fluoropolymer according to claim 30.

39. (Previously Presented) The solid polyelectrolyte membrane according to claim 38, wherein the multi-segmented fluoropolymer contains protonated sulfonic acid (SO_3H) groups as the sulfonic acid functional groups, and has a modulus of elasticity of at least $1X10^8$ dyn/cm^2 at 110°C or higher.

40. (Previously Presented) The solid polyelectrolyte membrane according to claim 39, wherein the equivalent weight of the whole multi-segmented fluoropolymer is 1600 or less.

41. (Previously Presented) The multi-segmented fluoropolymer according to claim 17, which has a block copolymer of a fluoropolymer chain segment A^1 containing sulfonic acid functional groups and a fluoropolymer chain segment B^1 containing no sulfonic acid functional groups, wherein:

the fluoropolymer chain segment A^1 containing sulfonic acid functional groups is a copolymer having a molecular weight of 5000 to 750000 and comprising:

(e) 1 to 50 mol% of at least one type of structural unit represented by Formula (1)

$$CX_2=CX^1-(O)_n\text{-}Rf\text{-}SO_2Y \qquad (1)$$

wherein X and X^1 may be the same or different and are each hydrogen or fluorine; Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_5 alkyl; Rf is C_1 to C_{40} divalent fluoroalkylene or C_1 to C_{40} divalent fluoroalkylene having ether bond(s); and n is 0 or 1, and,

(f) 99 to 50 mol% of at least one type of ethylenic monomer structural unit containing no sulfonic acid functional groups; and

the fluoropolymer chain segment B^1 is a fluoropolymer chain containing at least one type of ethylenic fluoromonomer unit and having a molecular weight of 3000 to 1200000.

42. (Previously Presented) The multi-segmented fluoropolymer according to claim 22, which has a block copolymer of at least two types of fluoropolymer chain segments C^1 and D^1 containing sulfonic acid functional groups, wherein:

the fluoropolymer chain segment C^1 is a copolymer having a molecular weight of 5000 to 750000 and comprising:

(g) 13 to 50 mol% of at least one type of ethylenic fluoromonomer structural unit containing sulfonic acid functional groups and represented by Formula (1)

$$CX_2=CX^1-(O)_n\text{-}Rf\text{-}SO_2Y \qquad (1)$$

wherein X and X^1 may be the same or different and are each hydrogen or fluorine; Y is F, Cl or OY^1 wherein Y^1 is hydrogen, alkali metal or C_1 to C_{40} divalent fluoroalkylene having ether bond(s); and n is 0 or 1, and

(h) 87 to 50 mol% of at least one type of ethylenic monomer structural unit containing no sulfonic acid functional groups; and

the fluoropolymer chain segment D^1 is a fluoropolymer chain having a molecular weight of 3000 to 1200000 and comprising:

(i) not less than 0.1 mol% but less than 13 mol% of at least one type of ethylenic fluoromonomer unit containing sulfonic acid functional groups and represented by Formula (a)

$$CX_2=CX^1-(O)_n\text{-}Rf\text{-}SO_2Y \qquad (1)$$

wherein X, X^1, Y, n and Rf are as defined above, and

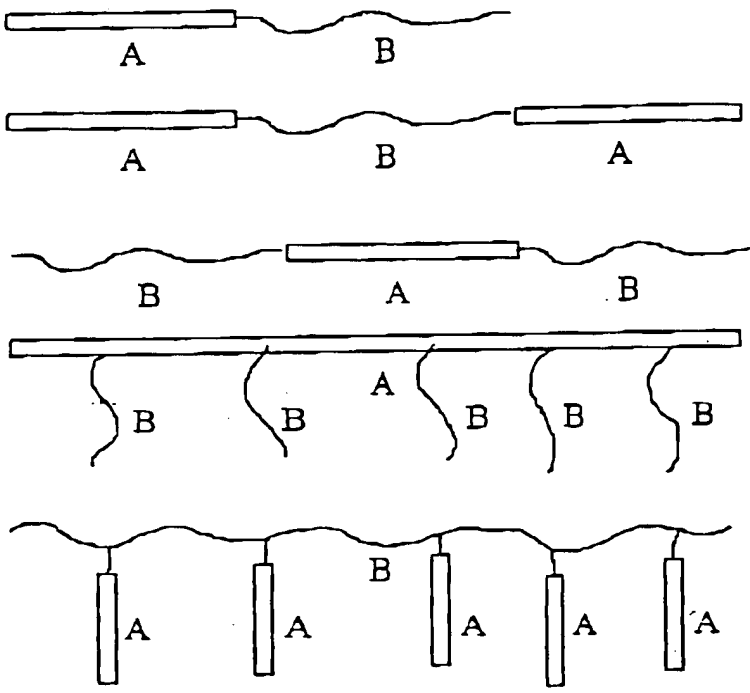
(j) more than 87 mol% but not more than 99.9 mol% of at least one type of ethylenic monomer unit containing no sulfonic acid functional groups.

43. (Previously Presented) The solid polyelectrolyte membrane according to claim 29, wherein the multi-segments fluoropolymer contains protonated sulfonic acid (SO_3H) groups as the sulfonic acid functional groups, and has a modulus of elasticity of at least $1X10^8$ dyn/cm^2 at 110°C or higher.

44. (Previously Presented) The solid polyelectrolyte membrane according to claim 43, wherein the equivalent weight of the whole multi-segmented fluoropolymer is 1600 or less.

APPENDIX 1

Copy of Fig. 1 From The Present Specification



A-B block copolymer

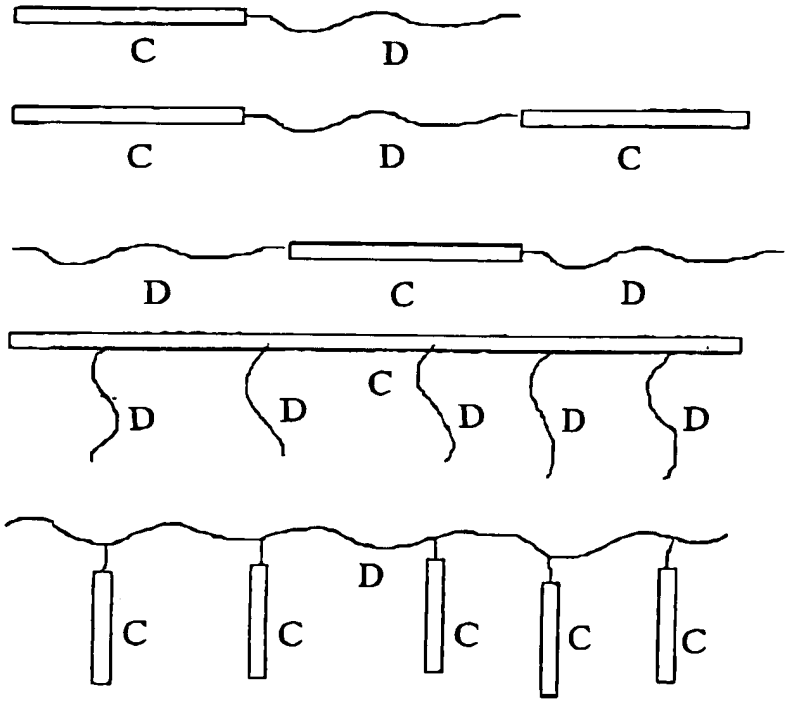
A-B-A block copolymer

B-A-B block copolymer

A-B graft copolymer

B-A graft copolymer

< Reference Figure >



C-D block copolymer

C-D-C block copolymer

D-C-D block copolymer

C-D graft copolymer

D-C graft copolymer

APPENDIX 2

Glossary of Polymer Terminology

Sources:

IUPAC:
"Glossary of Basic Terms in Polymer Science", Commission on Macromolecular Nomenclature, Macromolecular Division, International Union of Pure and Applied Chemistry, draft: May 13, 1991.

IUPAC:
"Definition of Terms Relating to Individual Macromolecules, Their Assemblies, and Dilute Solutions", Commission on Macromolecular Nomenclature, Macromolecular Division, International Union of Pure and Applied Chemistry, Pure and Appl. Chem., 61 (2), 211-241, 1989.

IUPAC:
"Stereochemical Definitions and Notations Relating to Polymers", Commission on Macromolecular Nomenclature, Macromolecular Division, International Union of Pure and Applied Chemistry, Pure and Appl. Chem., 53,733-752, 1981.

MIT Home Page | Back to title page | Back to syllabus | Ask the Professor

Future Plans:

- designate entries IUPAC91, IUPAC89 and IUPAC81.
- include all terms defined
- add equations

Click on a letter to jump that that section of the glossary

a: b: c: d: e: f: g: h: i: j: k: l: m: n: o: p: q: r: s: t: u: v: w: x: y: z:

a:

alternating copolymer:
a copolymer consisting of macromolecules comprising two species of monomeric units in alternating sequence. (IUPAC)

alternating copolymerization:
a copolymerization in which an alternating copolymer is formed. (IUPAC)

anionic polymerization:
an ionic polymerization in which the kinetic-chain carriers are anions. (IUPAC)

atactic macromolecule:
a regular macromolecule in which the configurational (base) units are not all identical. (IUPAC)

atactic polymer:
a substance composed of atactic macromolecules. (IUPAC)

b:

bead-rod model:
A model simulating the hydrodynamic properties of a chain macromolecule consisting of a sequence of beads, each of which offers hydrodynamic resistance to the flow of the surrounding medium and is connected to the next bead by a rigid rod which does not. The mutual orientation of the rods is random. (IUPAC)

bead-spring model:
A model simulating the hydrodynamic properties of a chain macromolecule consisting of a sequence of beads, each of which offers hydrodynamic resistance to the flow of the surrounding medium and is connected to the next bead by a spring which does not contribute to the frictional interaction but which is responsible for the elastic and deformational properties of the chain. The mutual orientation of the springs is random. (IUPAC)

→ block:
a portion of a macromolecule, comprising many constitutional units, that has at least one feature which is not present in the adjacent portions. (IUPAC)

→ block copolymer:
a copolymer that is a block polymer. In a block copolymer, adjacent blocks are constitutionally different, i.e., each of these blocks comprises constitutional units derived from different characteristic species of monomer or with different composition or sequence distribution of constitutional units. (IUPAC)

block macromolecule:
a macromolecule which is composed of blocks in linear sequence. (IUPAC)

block polymer:
a substance composed of block macromolecules. (IUPAC)

branch:
an oligomeric or polymeric offshoot from a branched chain. (IUPAC)

branch point:
a point on a chain at which a branch is attached. (IUPAC)

branched chain:
a chain with at least one branch point intermediate between the boundary units (i.e. the end-groups or other branch points). (IUPAC)

branched polymer:
a polymer, the molecules of which are branched chains. (IUPAC)